Jurnal Galaksi (Global Knowledge, Artificial Inteligent and Information System) E-ISSN: 3048-2399
Vol 1, No 2, August 2024 , pp.81-91
https://doi.org/10.70103/galaksi.v1i2.18

Temperature Humidity Control System and Fire Detection for Room Server Based Internet Of Things

I Gede Yudiana Putra[1] , I Gusti Made Ngurah Desnanjaya[2*] , I Gede Adnyana[3]

[1,2*,3] *Rekayasa Sistem Komputer, Institut Bisnis dan Teknologi Indonesia, Denpasar, Indonesia*
[1] *gedeyudiana26@gmail.com* , [2*] *ngurah.desnanjaya@ieee.org*, [3] *adnyana@instiki.ac.id*
**corresponding author*

ARTICLE INFO

Article history:
Received 10 August 2024
Revised 28 August 2024
Accepted 29 August 2024
Available Online 31 August 2024

Keywords *:*
Fire Detection;
Humidity Temperature Controls;
Internet Of Things;
Microcontrollers;
Sensors;

ABSTRACT

The objective of this research is to develop an Internet of Things (IoT)-based temperature, humidity, and fire detection control system to monitor server rooms at INSTIKI. The research methodology employed involved the collection of primary data through interviews and observations, as well as secondary data through a comprehensive literature review. The system is implemented using a variety of electronic components, including the NodeMCU ESP32, the DHT22 sensor, the MQ2 gas sensor, the KY-026 flame sensor, the PZEM-004t sensor, the infrared emitter LED, the 20x4 I2C LCD, the buzzer, the 5V modules adapters, the step-down modules, and the SIM800l modules. The findings of this study illustrate that the devised system is effective in monitoring temperature, humidity, smoke, fire, and electricity in the INSTIKI server room. The monitoring data is displayed via a web platform, while warning notifications are sent via SMS and Telegram in the event of dangerous situations, resulting in a 100% success rate for notification delivery. The testing of the air conditioning temperature controls using SMS also achieved a 100% success rate. However, the efficacy of the IR Remote is contingent upon the distance and position of the Infrared Emitter LED in relation to the AC's receiver sensors, as well as the quality of the signal received by the GSM800l module.

1. Introduction

The server room is a room used for the storage of servers, devices (including routers and hubs), and other operational system-related equipment, such as Uninterruptible Power Supplies (UPS) and air conditioning units. The server room is an invaluable asset for a company, as it houses an increasing number of customer applications and databases with each passing day. Therefore, it is of paramount importance that the room is kept in optimal condition at all times (Shun et al., 2020). It is of great importance to be aware of the condition of the server space in order to ensure the optimal functioning of the devices within. This entails maintaining the space in a condition that is conducive to the devices'

continued operation (Ridwan et al., 2020). Temperature and humidity are among the key environmental factors that can impact the performance of devices within a server (Utomo et al., 2019). Accordingly, the findings of the studies conducted by (Desnanjaya & Sugiartawan, 2022; Kurniawan et al., 2019) indicate that maintaining suitable temperature and humidity levels within the server room is crucial to prevent potential damage to devices.

The study by (Arifianto et al., 2022) indicates that low temperatures in server rooms result in increased energy costs, while elevated temperatures can damage server devices. Additionally, low humidity levels contribute to the accumulation of static electricity, while high humidity levels facilitate corrosion, potentially leading to short circuits. Additionally, there is a possibility of electrical short circuits occurring in the server room, which could potentially result in significant material and moral losses if not promptly addressed (Hassan & Jasim, 2021). It is therefore crucial to have an effective system in place to prevent and treat fires promptly (Siddiqui et al., 2022; Silaen & Riyadi, 2022). It is crucial to ascertain whether the electricity supply to the server room is active or inactive, as this is a prerequisite for ensuring the functionality of the essential devices that rely on a continuous power source (Krichen et al., 2021; Liao et al., 2019). In the event of a power outage, it is crucial to ascertain the status of the electricity supply with haste in order to facilitate an expedient resolution. It is of the utmost importance to ensure a stable power supply in the server room (Onibonoje et al., 2019), given that the server in question is designed to operate continuously for up to 24 hours. It is therefore imperative that a standard protective security system is in place to safeguard the devices within the server room from the outset, protecting them from fluctuations in temperature and humidity, as well as from fire and unauthorised access.

Based on the findings of interviews conducted with the Head of Department of Network and Security Systems at INSTIKI INDONESIA, it was revealed that INSTIKI has already implemented a monitoring system for temperature and humidity in its server room. This system employs the use of thermometers placed within the INSTIKI server room to facilitate direct monitoring of temperature and humidity. In the server room, an air conditioning unit is used to regulate the temperature. It is essential to utilise a remote control to facilitate direct temperature monitoring. It is crucial to monitor and control the temperature in a direct manner from the room. However, the server room at INSTIKI is situated on the fifth floor, which makes direct monitoring time-consuming and energy-intensive. Furthermore, the server room lacks a system capable of detecting both power outages and potential fire hazards, issuing notifications in the event of such incidents. It is therefore expected that the designed system will be capable of monitoring and controlling the temperature of the server room from a distance, as well as detecting and delivering notifications in the event of smoke, fire or a power cut in the Instiki server room.

Previous research has focused on the development of a temperature and humidity monitoring system with a DHT22 sensor for the retrieval of temperature and humidity data in the server room. This system is combined with a fire detector that uses a KY-026 flame sensor and an MQ2 sensor for the detection of fire or smoke in the server room. Furthermore, users are able to adjust the temperature of the air conditioning in the server room via the transmission of a text message. Additionally, a PZEM-004T sensor is included to ascertain whether the voltage in the server room is active or absent.

2. Literature Review

Study this based existing research conducted by (Putra & Aristana, 2022) is used as reference, where in the research the lift about implementation TIA-942 standard for development server room. On research This designed development in research previously with system that can monitoring and controlling temperature humidity server room so you can monitored and controlled with flexible, as well give notification warning with using SMS, telegram and web if detected smoke, fire and death electricity inside server room to be as fast as possible Possible Can handled so that it doesn't give rise to big loss.

First, research about problem fire alarm system carried out by (Suwarjono et al., 2021) with Detection Tool title Fire Using SMS. In the journal This lifted problem about danger condition

cables in dense residential areas resident as well as those installed in the home, because Lots get constraint like hit water, abrasions, bites rats, overuse and theft current That can cause happen fire. This study make solution form working tool as a current alarm exists fire and smoke detected. This tool using infrared sensors and combined with the MQ-2 smoke sensor as the data collector. Next, provide the data will processed by a microcontroller. If tool the detect exists fire and smoke then the GSM shield will send warning via SMS gateway (Silalahi et al., 2022). Method used direct discuss about designing device hardware as well as devices soft from tools, with create Block Diagrams, Circuits Overall Tools, and Design Tool Mechanic. For implications from researcher is A tools that can detect and send warning If there was smoke and fire detected. Time of smoke and fire detected, the buzzer sounds and the LCD shows voltage and smoke status. When fire smoke occurs, only the warning alarm is activated and automatically automatic send SMS alert indicating that has detect excessive smoke (Aryanti et al., 2021; Huang & Kieffer, 2019).

An additional study on the monitoring of temperature and humidity was conducted by (Hastuti & Wijaya, 2023). The objective of this work is to develop a user-friendly tool for monitoring temperature and humidity in server rooms. The tool will enable easy monitoring of the proper temperature and humidity levels from equipment located in the server room. Research methodology employed This is a prototyping technique. Findings of investigation This system and tools collect temperature and humidity data using the DHT11 sensor deployed in a server room connected to an internet network. The microcontroller processes the temperature and humidity data and sends it to an Android smartphone accessible to SIU server administrator staff through Blynk Apps. The acquired data was kept and examined to see if the temperature and humidity met the defined standards (Desnanjaya et al., 2022; Zhang et al., 2022).

Research methodology comprises several stages: Identification Problems, Literature study, Design System (Device Hardware, Software), and Testing (Desnanjaya & Sugiartawan, 2022; Setiawan et al., 2024). Findings of research investigations This tool is capable of monitoring both temperature and humidity using the DHT11 sensor as the collector for temperature and humidity. Once linked to the Microcontroller NodeMCU ESP8266, the breeder can access temperature and humidity data collected and analyzed by sensors and microcontrollers using the Telegram bot in the Telegram Messenger applications.

3. Research Methods

Data collection techniques are defined as the methods or techniques employed to gather as much data as possible to support a study. The researcher employed a variety of data collection techniques to gather information based on empirical evidence. These techniques were used to support the study's objectives. In the context of research, this approach entails the utilisation of both primary and secondary data collection methods. Primary data is defined as data collected directly from the primary source. The method employed for the collection of primary data is as follows:

Interview Method

An interview is a technique for data collection through a questioning process. It is an ongoing verbal exchange between the interviewing party and the interviewee, with the questions originating from the former and the answers from the latter. The researcher has already conducted an interview with the Head of Department for Network and Security System INSTIKI. Based on the results of this preliminary interview, the following findings have been obtained:

a. At INSTIKI there is 1 server room located in building 5 on the 5th floor .
b. Temperature and humidity room will influential to temperature machine and can happen corrosion to devices in the server room .
c. In the server room there are WiFi is backed up by UPS so If dead electricity wifi will still light up during Power reserve Still active .

d. In the server room there are Power possible backup turn on server devices , routers and switches for 20 minutes If happen dead electricity .
e. For server room at INSTIKI already done monitoring temperature and humidity room with use thermometer with method monitor direct from server room.
f. Desired notifications from SMS, Telegram and Web notifications .
g. The temperature set for the AC in the INSTIKI server room is 16°c.

Observation Method

The observation process is carried out in the server room of the INSTIKI campus. there are based on the observations that have been made, the following results are obtained

a. The server room at INSTIKI has size length 310cm, width 190cm and height 220cm.
b. Dimensions the server computer at INSTIKI is sized length 88cm, width 60cm and height 100cm.
c. In the server room, 1 Panasonic brand AC is used as cooler .
d. There is 1 piece thermometer hygrometer tool used For monitor temperature and humidity room .

In figure 1 block diagram for displays tools used on the system.

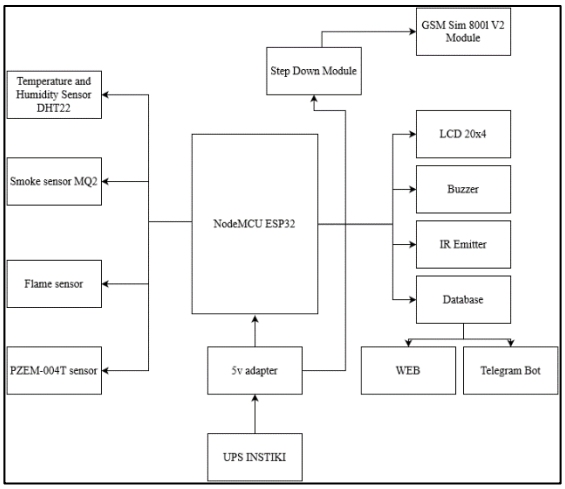

Fig.1. Block Diagram

Figure 2 displays the completed flowchart design of the system. The purpose of this flowchart is to describe a channel system by simplifying a sequence of processes or procedures, making them easily understandable and visible based on the order step of each operation.

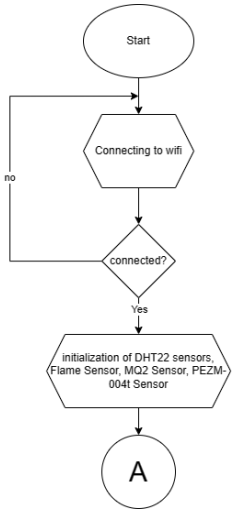

Fig. 2. System Flowchart

The sensor data is transmitted to the database and subsequently visualized on the monitoring web page. The user can configure the AC temperature via an SMS message, and the resulting temperature will be transmitted to the infrared emittre. It is visible in figure 3.

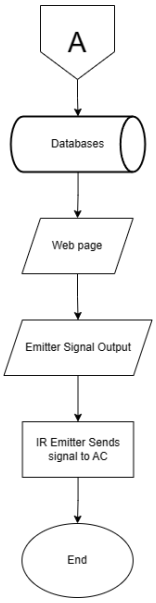

Fig. 3. Flowchart of Emitter Signal

All three MQ2 sensors detect smoke, if worth more than 5% will next to the notification process. The four KY-026 flame sensors detect fire, if detected will next to the notification process and then to the process of sending data.

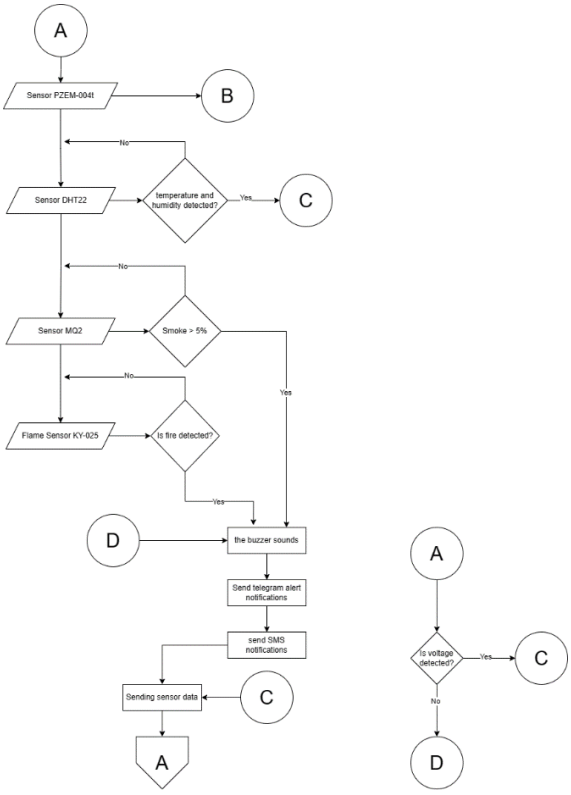

Fig. 4. Flowchart of Sensor Data

A Data Flow Diagram (DFD) is a graphical representation used to depict the data flow of a designed system.

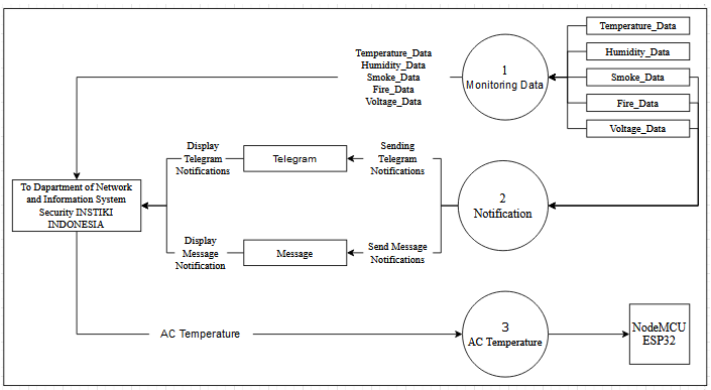

Fig. 5. Data Flow Diagram

Figure 6 displays a suite diagram of a system that controls temperature, humidity, and detects fire in an internet of things (IoT) computer room.

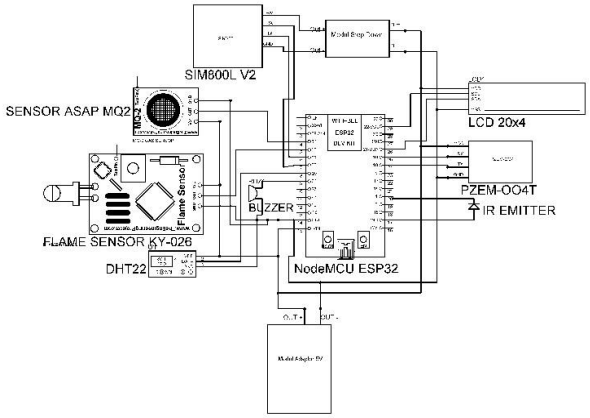

Fig. 6. Schematic

The provided diagram shown in figure 7 illustrates the design of a component box for controlling temperature, humidity, and detecting fire in an internet of things (IoT) based server room.

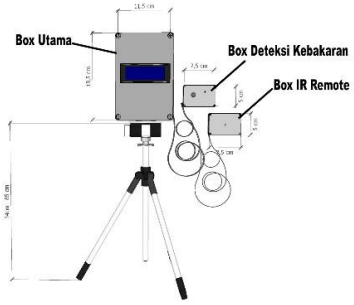

Fig. 7. 3D Design

4. Results and Discussions

At this stage, the testing system has been completed in a manner that ensures that all necessary components are in position for the implementation study, which is located in the INSTIKI server

room. Beginning with the testing of the connection, the process of receiving data from sensors, the display of the data on the LCD and the web, the arrangement of the AC temperature via SMS, and the testing of alarms and notifications warning.

4.1 Data Description

This stage has been completed in order to determine the capability of the instrument that was designed. Set the system in an automatic manner to connect to the existing WiFi. The INSTIKI-SRV wifi is the WiFi that is utilized in the INSTIKI server room. Figure 4.28 illustrates the test image connection wifi utility. "Connect wifi: INSTIKI-SRV" will be displayed on the LCD. The LCD will display the connected status and the IP address if the connection is successful.

Table 1. Connection Testing

Test	First Tool Turned on	Wifi Dead and Back Conditions
1	Connected IP 192.168.1.9	Connected IP 192.168.1.9
2	Connected IP 192.168.1.9	Connected IP 192.168.1.9
3	IP connected 192.168.1.9	IP connected 192.168.1.9
4	IP connected 192.168.1.9	IP connected 192.168.1.9
5	Connected IP 192.168.1.9	Connected IP 192.168.1.9
6	Connected IP 192.168.1.9	Connected IP 192.168.1.9
7	Connected IP 192.168.1.9	Connected IP 192.168.1.9
8	Connected IP 192.168.1.9	Connected IP 192.168.1.9
9	Connected IP 192.168.1.9	Connected IP 192.168.1.9
10	Connected IP 192.168.1.9	Connected IP 192.168.1.9

The following are the results of the sensors used in the System Control Temperature Humidity And Detection Fire in Internet of Things Based Server Room. The 20x4 LCD is used to display the data that the sensors have collected. The parameters that can be viewed on a 20x4 LCD are pln. The voltage of electricity for displays, the temperature of the room for displays, and the humidity of the room for displays are all marked. Smoke: Provides a smoke percentage, Fire: Indicates the status of a fire, and AC: Indicates the temperature of an air conditioner. The system can autonomously display real-time monitoring data based on the results of the current testing conducted in the INSTIKI server room for seven days.

Fig. 8. LCD Display

Following is display of server room monitoring data displayed via the website.

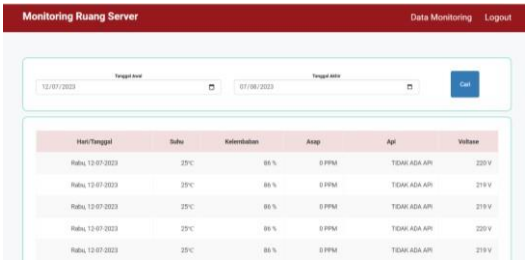

Fig. 9. Website View

The data that is displayed on the website is derived from the previous database that was provided by NodeMCU ESP32. The website also includes pages that exhibit the history of previous monitoring data that has been obtained and stored in the database. This page functions as a data viewer for monitoring telemetry data within the server room.

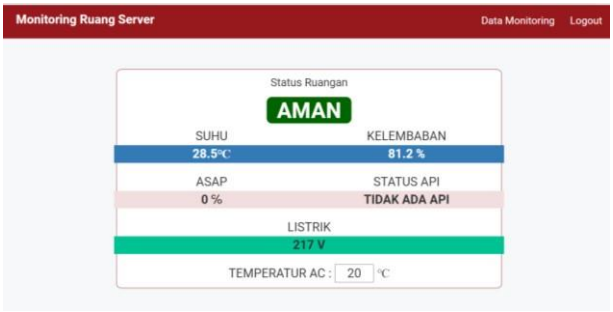

Fig. 10. Monitoring Data Display

Air Conditioner (AC) temperature testing is conducted in the INSTIKI server room. The AC temperature is adjusted via SMS by utilizing a variety of order message text, including "on" to activate the AC, "off" to deactivate the AC, "up" to increase the AC temperature, and "down" to decrease the AC temperature. Each of the ten tests that he ordered was conducted. Every order can function with Good during the test.

Table 2. IR Remote Testing

Test	Order	Condition beginning	AC condition after arranged with SMS	Results
1	User sends on command for turn on the AC	AC inside circumstances dead	AC responds and turns on	IR Remote successful turn on the AC
2	User sends off command for turn off the AC	AC inside circumstances life	AC responds and turns off	IR Remote successful turn off the AC
3	User sends command up for raise AC temperature	AC inside circumstances life	AC responds with beeps 1 time	IR Remote successful raise AC temperature
4	User sends down command for lower AC temperature	AC inside circumstances life	AC responds with beeps 1 time	IR Remote successful lower AC temperature

This stage has been completed with the testing of alarms and notifications that warn of potential systemic risks. Testing is conducted under the condition that the sensor detects dangerous objects. The NodeMCU ESP32 processes the data and generates output in the form of voice notifications via

SMS and Telegram, as well as vocal output from buzzers. Table 3 displays the results of the data assessment. Figures 12 and 11 illustrate notification examples.

The currently conducted testing has yielded the following results: the designed system is capable of accurately reading temperature and humidity, smoke, fire, and voltage electrical in the server room. The 20x4 LCD and the server room monitoring website page can both display the reading results obtained by the sensor as "Good."

In the event of an emergency in the server room, the system can also provide a warning alarm via buzzer and notification via SMS and Telegram. The system's IR remote is highly effective in managing the air conditioning in the server room.

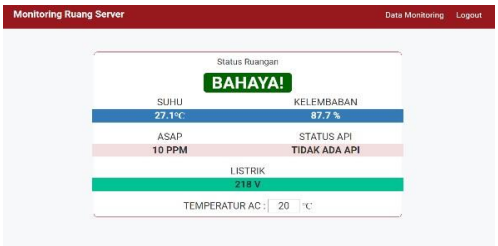

Fig.11. Website Notification

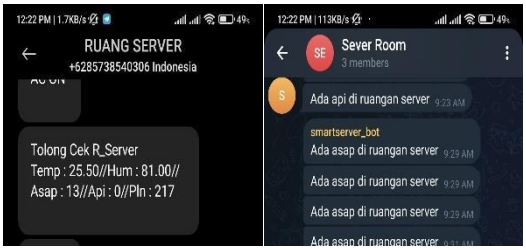

Fig.12. SMS and Telegram Notifications

Table 3. Testing Whole Notifications

Condition	Responding Sensor			Buzzers	Notifications	
	PZEM -004T sensor	MQ2	Flame Sensor KY-026		SMS	Telegram
Room given smoke with use incense as many as 14 pieces	-	✓	-	Sounds	✓	✓
In the room turned on fire with use gas lighter	-	-	✓	Sounds	✓	✓
The PZEM-004T sensor reading power is turned off	✓	-	-	Sounds	✓	✓
In the room turned on fire with burn paper	-	✓	✓	Sounds	✓	✓

The table shows test results from several conditions using the PZEM-004T, MQ2, and Flame Sensor KY-026 sensors, as well as responses to various notifications such as SMS and Telegram, including buzzer activation. In some scenarios, such as when the room is exposed to smoke from incense sticks or when a fire is lit with a gas lighter, the Flame sensor KY-026 or the MQ2 sensor responds differently. For example, when the room was given smoke from 14 pieces, only the MQ2 sensor was active, causing the buzzer to sound and sending notifications via SMS and Telegram. Meanwhile, when a fire is lit with a gas lighter, only the KY-026 flame sensor detects the flame, generates a buzzer sound and sends a notification.This test shows that the system can detect various dangerous conditions, both from the presence of smoke and fire, and can automatically provide warnings through notifications on SMS and Telegram, as well as buzzer activation. This shows that the system is effective in providing early warning of potential fire hazards.

5. Conclusion

The following conclusion can be drawn from the experiments conducted on the System Control Temperature Humidity And Detection Fire in Internet of Things Based Server Room: 1) A fire occurred in the internet of things-based server room during the design and construction of temperature control systems, humidity detection, and other processes. The fire began at the initial stage, which involved the design of systems, the fabrication of tools, and the testing of the systems. The entire system is designed to function efficiently and effectively in accordance with the writer's expectations. 2) Based on the results of the temperature control system testing, humidity, and detection The fire that occurred in the internet of things-based server room was the result of the system's design, which can monitor data in the server room via LCD and website and provide notifications in the event of an emergency via SMS messages, telegrams, and alerts on website pages.

References

Arifianto, D., Sulistyono, A., & Nilogiri, A. (2022). Sistem Monitoring Suhu Dan Kelembaban Ruangan Server Berbasis Arduino Menggunakan Metode Fuzzy Logic Dengan Buzzer Dan Telegram Bot Sebagai Notifikasi. *JUSTINDO (Jurnal Sistem Dan Teknologi Informasi Indonesia)*, *7*(1), 67–75. https://doi.org/10.32528/justindo.v7i1.5135

Aryanti, A., Mekongga, I., & Dewi, R. S. (2021). GPS-Based fire detection system (global positioning system) and SMS gateway. *IOP Conference Series: Materials Science and Engineering*, *1108*(1), 12023. https://doi.org/10.1088/1757-899X/1108/1/012023

Desnanjaya, I. G. M. N., Ariana, A. A. G. B., Nugraha, I. M. A., Wiguna, I. K. A. G., & Sumaharja, I. M. U. (2022). Room Monitoring Uses ESP-12E Based DHT22 and BH1750 Sensors. *Journal of Robotics and Control (JRC)*, *3*(2), 205–211. https://doi.org/10.18196/jrc.v3i2.11023

Desnanjaya, I. G. M. N., & Sugiartawan, P. (2022). Controlling and Monitoring of Temperature and Humidity of Oyster Mushrooms in Tropical Climates. *IJEIS (Indonesian Journal of Electronics and Instrumentation Systems)*, *12*(1), 69–80. https://doi.org/10.22146/ijeis.73346

Hassan, J. A., & Jasim, B. H. (2021). Design and implementation of internet of things-based electrical monitoring system. *Bulletin of Electrical Engineering and Informatics*, *10*(6), 3052–3063. https://doi.org/10.11591/eei.v10i6.3155

Hastuti, D., & Wijaya, A. S. (2023). Designing a Surveillance System, Temperature and Humidity Detection based on Internet of Things (IoT) in the Server room University of PGRI Adi Buana Surabaya. *BEST: Journal of Applied Electrical, Science, & Technology*, *5*(2), 46–54. https://doi.org/10.36456/best.vol5.no2.8028

Huang, Q., & Kieffer, K. (2019). An intelligent internet of things (IoT) sensor system for building environmental monitoring. *Journal of Mobile Multimedia*, 29–50. https://doi.org/10.13052/1550-4646.15122

Krichen, M., Mechti, S., Alroobaea, R., Said, E., Singh, P., Khalaf, O. I., & Masud, M. (2021). A formal testing model for operating room control system using internet of things. *Computers, Materials & Continua*, *66*(3), 2997–3011. https://doi.org/10.32604/cmc.2021.014090

Kurniawan, D. E., Iqbal, M., Friadi, J., Borman, R. I., & Rinaldi, R. (2019). Smart monitoring temperature and humidity of the room server using raspberry pi and whatsapp notifications. *Journal of Physics: Conference Series*, *1351*(1), 12006. https://doi.org/10.1088/1742-6596/1351/1/012006

Liao, L.-D., Wang, Y., Tsao, Y.-C., Wang, I.-J., Jhang, D.-F., Chu, T.-S., Tsao, C.-H., Tsai, C.-N., Chen, S.-F., & Chuang, C.-C. (2019). Design and validation of a multifunctional android-based smart home control and monitoring system. *Ieee Access*, *7*, 163313–163322. https://doi.org/10.1109/ACCESS.2019.2950684

Onibonoje, M. O., Bokoro, P. N., Nwulu, N. I., & Gbadamosi, S. L. (2019). An IoT-Based Approach to Real-Time Conditioning and Control in a Server Room. *2019 International Artificial Intelligence and Data Processing Symposium (IDAP)*, 1–6. https://doi.org/10.1109/IDAP.2019.8875880

Putra, I. D. P. G. W., & Aristana, M. D. W. (2022). IMPLEMENTASI TIA-942 PADA

PEMBANGUNAN RUANG SERVER (STUDI KASUS: UPT SIMJAR STMIK STIKOM INDONESIA). *Jurnal Teknologi Informasi Dan Komputer*, *8*(1). https://doi.org/10.36002/jutik.v8i1.1580

Ridwan, M., Djamaludin, D., & Roqib, M. (2020). Prototype Monitoring Temperature and Humidity Sensor Room Server-Based Internet of Things (IOT). *Proceedings of the First International Conference of Science, Engineering and Technology, ICSET 2019, November 23 2019, Jakarta, Indonesia*. https://doi.org/10.4108/eai.23-11-2019.2301576

Setiawan, I. P. E., Desnanjaya, I. G. M. N., Supartha, K. D. G., Ariana, A. A. G. B., & Putra, I. D. P. G. W. (2024). Implementation of Telegram Notification System for Motorbike Accidents Based on Internet Of Things. *Jurnal Galaksi*, *1*(1), 1–11. https://doi.org/10.70103/galaksi.v1i1.1

Shun, W. G., Muda, W. M. W., Hassan, W. H. W., & Annuar, A. Z. (2020). Wireless sensor network for temperature and humidity monitoring systems based on NodeMCU ESP8266. *Advances in Cyber Security: First International Conference, ACeS 2019, Penang, Malaysia, July 30–August 1, 2019, Revised Selected Papers 1*, 262–273. https://doi.org/10.1007/978-981-15-2693-0_19

Siddiqui, O. A., Shaikh, M. K., Tahir, M., Urooj, A., Khan, M. A., & Rahim, I. U. (2022). Atmospheric Environment Monitoring System Based on Wireless Sensor Prototype to Prevent Data Centers. *Pakistan Journal of Engineering and Technology*, *5*(2), 79–86. https://doi.org/10.51846/vol5iss2pp79-86

Silaen, M. G., & Riyadi, M. A. (2022). Design of Early Detection System for Home Security Based on Smartphone. *2022 9th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, 76–80. https://doi.org/10.1109/ICITACEE55701.2022.9924055

Silalahi, A., Hartama, D., Kirana, I. O., Gunawan, I., & Sumarno, S. (2022). Rancang Bangun Alat Pendeteksi Kebocoran Pada Tabung Gas Menggunakan Arduino Berbasis SMS. *Jurnal Krisnadana*, *1*(3), 48–58. https://doi.org/10.58982/krisnadana.v1i3.178

Suwarjono, S., Wayangkau, I. H., Istanto, T., Rachmat, R., Marsujitullah, M., Hariyanto, H., Caesarendra, W., Legutko, S., & Glowacz, A. (2021). Design of a home fire detection system using Arduino and SMS gateway. *Knowledge*, *1*(1), 61–74. https://doi.org/10.3390/knowledge1010007

Utomo, M. A. P., Aziz, A., & Harjito, B. (2019). Server room temperature & humidity monitoring based on Internet of Thing (IoT). *Journal of Physics: Conference Series*, *1306*(1), 12030. https://doi.org/10.1088/1742-6596/1306/1/012030

Zhang, D., Ji, H., Li, Z., & Ge, H. (2022). Design of building environment detection system for architectures based on internet of things. *Computational Intelligence and Neuroscience*, *2022*(1), 5438305. https://doi.org/10.1155/2022/5438305